






New record of Ocelot, *Leopardus pardalis* (Linnaeus, 1758) (Felidae), in an Atlantic Forest fragment in the Pernambuco Endemism Center, northeastern Brazil

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Abstract

The Pernambuco Endemism Center is a key region for the maintenance of biodiversity of the Brazilian Atlantic Forest. Inventories of the medium-sized terrestrial mammals in this region are scarce, and several information gaps still remain. We conducted a camera trap survey at the Tapacurá Ecological Station, São Lourenço da Mata, Pernambuco. We obtained new records of at least four females and three male individuals of Ocelot, *Leopardus pardalis* (Linnaeus, 1758). The records provide important data about occurrence and distribution of a threatened population of this mesocarnivore in northeastern Brazil.

Keywords

Biodiversity hotspot, camera traps, geography, mammal

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Introduction

Current rates of biodiversity loss are driven by anthropogenic pressures resulting in steep declines in populations (Dirzo et al. 2014). In the Atlantic Forest of South America, habitat loss and fragmentation represent major threats to biodiversity maintenance and promote habitat

homogenization (Lôbo et al. 2011), reduction of diversity (Wilson et al. 2016), and local extinctions (Galetti et al. 2017; Hilário et al. 2017). In this context, the defaunation process is advancing at a greater rate than efforts to fill knowledge gaps on the distribution of species. The lack

of data has hampered an effective conservation agenda for species and their habitats (Gorenflo and Brandon 2006; Collen et al. 2008).

The Atlantic Forest had an original extent of approximately 150 million hectares distributed across eastern Brazil, southern Paraguay, and northern Argentina (Ribeiro et al. 2009). The pronounced and unorganized economic exploitation in Brazil (e.g., coffee and sugar cane monocultures and cattle) during the last 500 years were responsible for the disappearance of about 72% of its original vegetation (Weinstein and Dean 1996; Lembi et al. 2020). Located to the north of the São Francisco River, the portion of Atlantic Forest known as the Pernambuco Endemism Center (PEC) (Tabarelli et al. 2006; Mendes-Pontes et al. 2016) is highly biodiverse and it is inserted in a now highly fragmented landscape (Melo et al. 2013). Most of the Atlantic Forest fragments in the PEC are small and isolated, and less than 7% of the original vegetation cover remains (Roda 2003; Melo et al. 2013).

The PEC is a refuge for several mammals that are rare in the Atlantic Forest, such as Blonde Capuchin Monkey [*Sapajus flavius* (Schreber, 1799)], Red-handed Howler Monkey [*Alouatta belzebul* (Linnaeus, 1766)], Brazilian Cottontail [*Silvilagus brasiliensis* (Linnaeus, 1758)], Jack's Red-rumped Agouti [*Dasyprocta iacki* Feijó & Langguth, 2013], and Ocelot [*Leopardus pardalis* (Linnaeus, 1758)]. Many of these species are under threat in the forest fragments in the PEC (Garbino et al. 2018). These species play key ecological roles in these areas, acting as primary consumers, seed dispersers, and regulators of prey populations, and, thus, they provide unique ecosystem services (Bogoni et al. 2018).

The Ocelot has a wide distribution in the Americas, occurring from southern United States through Central America to South America, where it occurs in all countries, except Chile (Emmons and Feer 1997; Di Bitetti et al. 2006). It is present in almost all of Brazil and is the most abundant mesocarnivore in Atlantic Forest fragments when large top-chain predators are absent (Mas-sara et al. 2018). The presence of Ocelots and absence of top predators negatively affect the smaller sympatric felid species due to the predatory potential of the former, in what is known as the “Pardalis effect” (Oliveira et al. 2010). Ocelots are active during the night and in the early hours of the day (Di Bitetti et al. 2006). This species is categorized as Least Concern in the Brazilian and global Red Lists (Oliveira et al. 2013; Paviolo et al. 2015).

In the Northeast Region of Brazil, the presence of *L. pardalis* is poorly documented and only a few recent studies have recorded the species (e.g., Júnior 2007; Mendes-Pontes et al. 2016; Beltrão et al. 2018). Therefore, we report on new records of *L. pardalis* in an Atlantic Forest fragment. These new data were collected in camera-trapping field survey in the Tapacurá Ecological Station, state of Pernambuco, in northeastern Brazil.

Methods

The study was conducted in the Tapacurá Ecological Station (08°02'17"S, 035°11'28"W at approximate center), a protected area located in the municipality of São Lourenço da Mata, state of Pernambuco, Brazil. The ecological station has an area of 776 ha, where 382 ha are composed of semideciduous seasonal forest (Andrade and Rodal 2004). The sampling effort consisted of 16 camera-trap stations, each with an Amcrest ATC-1201 12 MP digital game trail camera. In May 2017, we conducted a pilot sampling during 6 d, and in 2019 we started a systematic effort to survey the area. The camera traps operated between January and March 2019 (rainy season), and between May and July 2019 (dry season). The cameras were installed at approximately 40 cm from the forest ground, without bait, and with a minimum spacing of 350 m to guarantee the independence of the records (Galetti et al. 2017). They were distributed on the trails to cover most of the Tapacurá Ecological Station area (Fig. 1). These cameras were set to record videos (1080 pixels) with duration of 30 s for more accurate nocturnal records and to detect possible behaviors of the animals, with a 1-min interval between records. It is possible to identify the sex of ocelot in videos due the conspicuousness of the male's scrotum, while for females we only consider the images in which it is possible to clearly see the absence of testicles. Videos that did not allow gender identification (i.e., high-motion blur, only head or tail in the image) were considered unidentified.

Results

We obtained a total sampling effort of 13,801 h of photographic trapping. *Leopardus pardalis* individuals were recorded in seven of the 16 camera trap stations installed in the site (Fig. 1). We obtained eight independent records, where one was recorded in May 2017 during the pilot study and seven on video during the systematic field survey. All records of the species were performed at night between 20:00 and 04:00 h. Among the individuals with identified sex ($n = 8$), females represented 50% of the records (Tables 1, 2; Fig. 2). It was not possible to identify whether all the individuals were or not adults.

Table 1. Records of *Leopardus pardalis* at the Tapacurá Ecological Station, São Lourenço da Mata, Pernambuco, Brazil. All coordinates are in WGS84 datum. Sex: M = male; F = female; UN = undetermined.

| Camera | Record type | Latitude, longitude | Sex | Date | Time |
|--------|-------------|-------------------------|-----|------------|-------|
| 2 | Video | 08°01'17"S, 036°06'46"W | F | 09.II.2019 | 23:57 |
| 2 | Video | 08°01'17"S, 036°06'46"W | F | 10.II.2019 | 04:44 |
| 3 | Video | 08°01'17"S, 035°07'02"W | M | 18.II.2019 | 20:05 |
| 4 | Video | 08°01'09"S, 035°06'59"W | UN | 31.I.2019 | 01:58 |
| 4 | Video | 08°01'09"S, 035°06'59"W | F | 05.II.2019 | 23:49 |
| 5 | Video | 08°01'21"S, 035°07'10"W | UN | 20.II.2019 | 00:35 |
| 6 | Video | 08°01'33"S, 035°07'17"W | M | 01.II.2019 | 22:20 |
| 8 | Video | 08°01'33"S, 035°07'27"W | F | 12.II.2019 | 20:17 |
| 12 | Photo | 08°02'02"S, 035°11'41"W | M | 19.V.2017 | 21:00 |

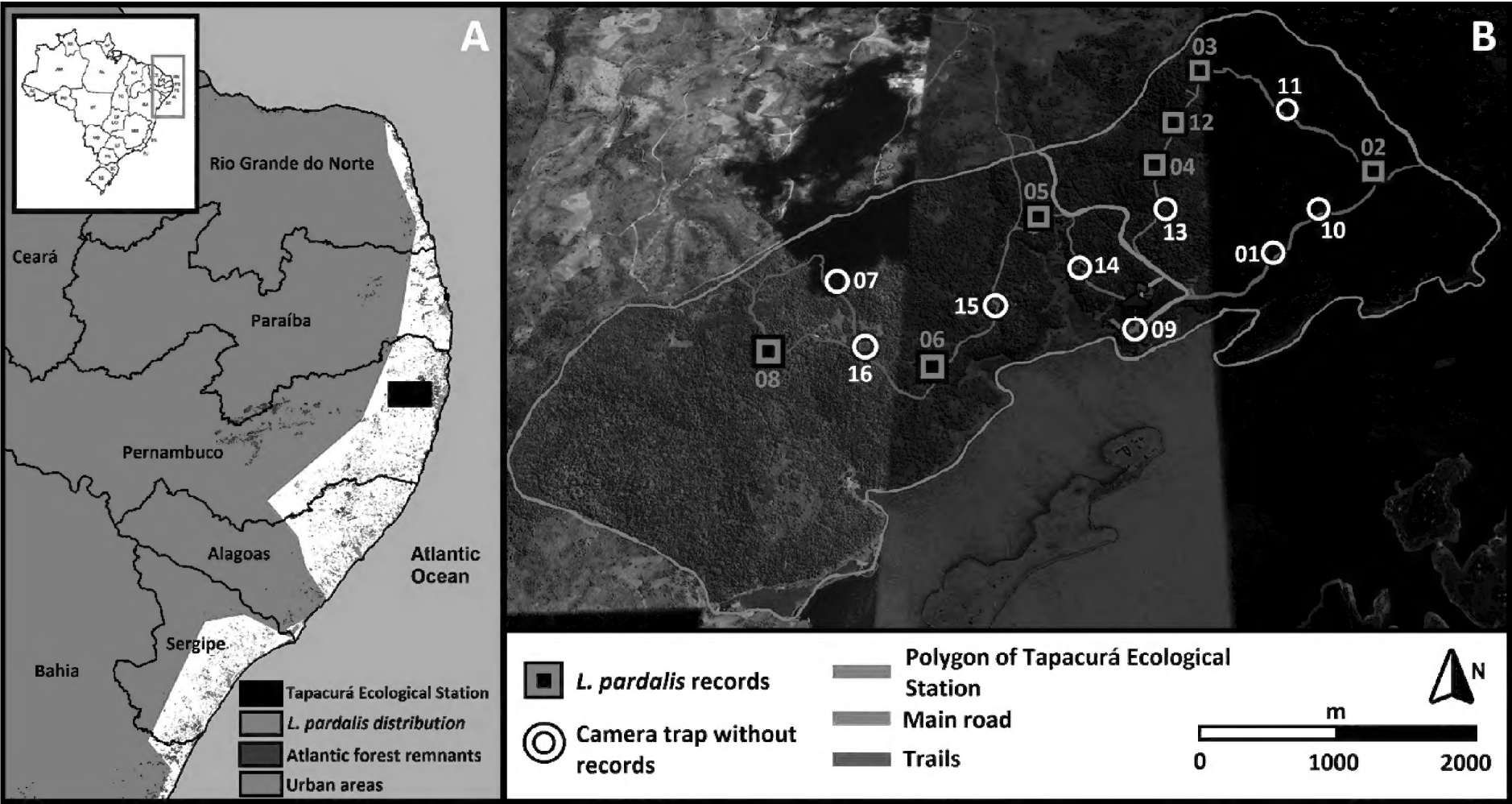


Figure 1. A. Partial map of the northeastern region of Brazil, showing part of the IUCN distribution polygon of *Leopardus pardalis* (see Paviolo et al. 2015), forest fragments, urban areas, and location of the study area. B. Map of the Tapacurá Ecological Station, Pernambuco, Brazil, representing the locations of the sampling stations of the camera traps, where the red squares represent the records for this species, and the white circles the absence of records for this species.



Figure 2. Images of *L. pardalis* in four different camera trap stations at the Tapacurá Ecological Station, Pernambuco, Brazil. A. May 2017. B–D. February 2019.

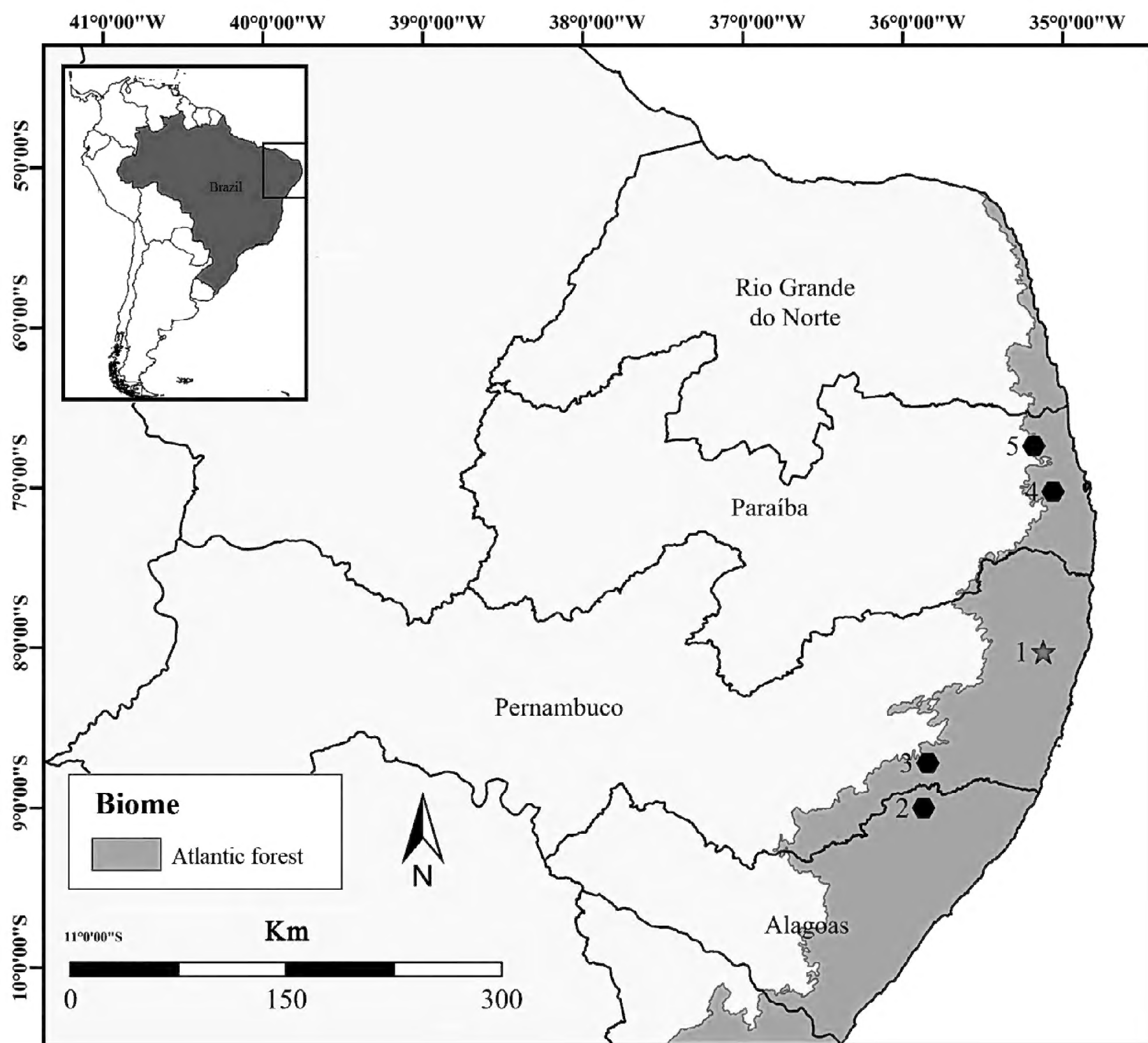


Figure 3. Records of *Leopardus pardalis* in the Atlantic Forest of the Pernambuco Endemism Center. Red star (1) = new records from Estação Ecológica Tapacurá. Black hexagons = literature records (Table 2).

New records. BRAZIL – Pernambuco • São Lourenço da Mata, Estação Ecológica Tapacurá; 08°01'17"S, 036°06'46"W; 19.V.2017; L.G. Silva leg.; adult; 1 ♂ • same locality; 08°01'17"S, 036°06'46"W; 09.II. 2019; D.M.S. Ramos leg.; adult; 1 ♀ • same locality; 08°01'17"S, 036°06'46"W; 10.II.2019; D.M.S. Ramos leg.; adult; 1 ♀ • same locality; 08°01'17"S, 035°07'02"W; 18.II.2019; D.M.S. Ramos leg.; adult; 1 ♂ • same locality; 08°01'17"S, 035°07'2"W; 31.I.2019; D.M.S. Ramos leg.; adult; 1 sex indet. • same locality; 08°01'09"S, 035°06'59"W; 05.II.2019; D.M.S. Ramos leg.; adult; 1 ♀ • same locality; 08°01'21"S, 035°07'10"W; 20.II.2019; D.M.S. Ramos leg.; adult; 1 unidentified sex; • same locality; 08°01'33"S, 035°07'17"W; 01.II.2019; D.M.S. Ramos leg.; adult; 1 ♂ • same locality; 08°01'33"S, 035°07'27"W; 12.II.2019; D.M.S. Ramos leg.; adult; 1 ♀.

Identification. Ocelots were identified following the morphological characteristics described by Emmons and Feer (1997), Murray and Gardner (1997), Oliveira and Cassaro (1997), Sunquist and Sunquist (2002), Nascimento and Feijó (2017), and Hunter and Barrett (2019).

We observed the relatively large body (in comparison to other small spotted felids), short tail in relation to head and body, solid black markings in the form of open rosettes which may be separate or may coalesce in longitudinal bands, and the anterior orientation of the fur on the nape. This pattern of longitudinal bands, in addition to the larger size and proportionately short tail, distinguishes *L. pardalis* from other Brazilian felids, such as the sympatric *Leopardus emiliae* (Thomas, 1914), in which the circular rosettes do not coalesce to form lateral bands.

Discussion

This study is the first systematic survey of medium-sized mammals (>1 kg; Paglia et al. 2012) conducted with camera traps in this protected area. In a previous study using a diurnal census in the area, Oliveira (2012) did not record the ocelot. It is likely that the methodology introduced a bias towards not detecting small felids in the area. In Oliveira's study, only diurnal census, traces, and Tomahawk (50 × 21.5 × 20 cm) and Sherman traps (31 × 8 × 9

Table 2. Records of *Leopardus pardalis* at the Pernambuco Endemism Center of the Atlantic Forest of Brazil. All coordinates are in WGS84 datum.

| ID no. | Record type | Latitude, longitude | State | Source |
|--------|-------------|-------------------------|------------|----------------------------------|
| 1 | Camera trap | 08°01'33"S, 035°07'17"W | Pernambuco | This study |
| 2 | Sighting | 09°00'00"S, 035°52'12"W | Alagoas | Mendes Pontes et al (2016) |
| 3 | Track | 08°43'12"S, 035°50'38"W | Pernambuco | Silva Jr. & Mendes Pontes (2008) |
| 4 | Road killed | 07°01'23"S, 035°03'39"W | Paraíba | Beltrão et al (2018) |
| 5 | Camera trap | 06°44'15"S, 035°10'50"W | Paraíba | Beltrão et al (2018) |

cm) for small mammals were used. Although sampling with camera traps is recommended and employed in studies with cryptic mammals such as Ocelot (Linkie et al. 2013), long-term studies or in different seasons using this procedure also contribute to increase the detection rates (Harmsen et al. 2021). Our records also fill an existing gap in the known geographic distribution of this species. The previous records were made at 54 km south of Tapacurá Ecological Station (Table 2; Fig. 3), where one individual was identified from footprints in the large and preserved Atlantic Forest fragment (630 ha) at Reserva Particular do Patrimônio Natural Frei Caneca, Pernambuco (Silva Jr. and Mendes-Pontes 2007). Another nearby record was made in a large Atlantic Forest fragment (3,478 ha) located in Alagoas, 127 km to south (Table 2; Fig. 3), with one individual being recorded using line transect (Mendes-Pontes et al. 2016). Finally, *L. pardalis* was also previously recorded approximately 199 km to the north of our study area, where one road-killed adult male was documented (Table 2; Fig. 3). There are also 14 previous records obtained from camera traps in two forest fragments inserted in the Reserva Biológica Guaribas, Paraíba (Table 2; Fig. 3) (Beltrão et al. 2018). The International Union for Conservation of Nature (IUCN) does not predict the presence of Ocelot for this portion of the Atlantic Forest in northeastern Brazil (Paviolo et al. 2015; Fig. 1). Previous studies have recorded *L. pardalis* from the Caatinga (Feijó and Langguth, 2013; Marinho et al. 2017) and some recent records from Atlantic Forest fragments situated in the state of Paraíba (Beltrão et al. 2018). Garbino et al. (2018) although pointed out the presence of species in the PEC, they did not give precise locality data. In this sense, our new records are extremely important for updating of the distribution of Ocelot at the continental scale, as well as fill a gap in the central portion of the Pernambuco Endemism Center (Fig. 3).

We obtained 16 records of Ocelot at the Tapacurá Ecological Station; however, it was possible to determine the sex of individuals in only seven records. Three males and four females were identified, and at least one male and one female were adults. Morphological characteristics such as body size and shape for both individuals could be demonstrating the reproductive age (Fig. 2). Thus, we hypothesize that this protected area has favored the survival of species not only after to birth but until the reproductive age. We found that Ocelots avoided the areas closer to the station's headquarters where people and vehicles often transit. This behavior is expected for an elusive species and especially for small and

medium-sized wild felids (Paviolo et al. 2008; Di Bitetti et al. 2010).

Some species of large carnivores such as Jaguar [*Panthera onca* (Linnaeus, 1758)] and Cougar [*Puma concolor* (Linnaeus, 1771)], and large herbivores such as Tapir [*Tapirus terrestris* (Linnaeus, 1758)] and Gray Brocket Deer [*Mazama gouazoubira* (Fischer, 1814)] are extirpated from PEC (Garbino et al. 2018; Oliveira 2012). This pattern of local extinctions of medium-sized and large mammals, especially top predators, is strongly linked to anthropogenic pressures (e.g., Tabarelli et al. 2006; Rezende 2018; Lembi et al. 2020; Bogoni et al. 2020). Ocelots are ecologically versatile and can benefit from the absence of these top predators by occupying the ecological niches left by them (Crooks and Soulé 1999; Di Bitetti et al. 2006, 2010). Thus, Ocelots can play an important and complementary ecological role. Our findings represent new records of an Ocelot population in a fragment of the highly deforested Atlantic Forest. This study presents a new area to be incorporated in conservation strategies focused on mammals in the northeastern region of Brazil.

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